4.3 GEOLOGY AND SOILS

4.3.1 INTRODUCTION

This section discusses the geologic, soil, and seismic conditions of the Highland Estates project site and analyzes potential project impacts associated with these resources. The issues of primary concern for this project related to geologic and soil resources are seismic ground shaking, unstable soils and slope stability, erosion, and potential risks associated with development on expansive soils.

Sources of information used in this analysis include:

1. Geotechnical Investigation and Geologic Hazards Review for Four Single-Family Homes at Ticonderoga Drive, prepared by TRC Lowney February 7, 2006;
2. Fault Activity Map of California and Adjacent Areas, California Department of Conservation, Division of Mines and Geology, 1994;
3. United States Geological Survey (USGS)/California Geological Survey (CGS) Probabilistic Seismic Hazards Assessment Model, 2002;
4. California Department of Conservation Division of Mines and Geology, Open File Report 96-08;
5. Preliminary and Supplemental Geologic/Geotechnical Investigation Reports for Highland Estates by Soil Foundations Systems, 1990/1994;
6. Alquist-Priolo Earthquake Fault Zone Map for San Mateo 7.5 Minute Quadrangle;
7. Slope Stability During Earthquakes Map for San Mateo County;
8. Natural Resource Conservation Service, Soil Survey for San Mateo County, Eastern Part, and San Francisco, CA; ~~and~~
9. Geologic Evaluation, Environmental Impact Report for Highlands Estates Residential Development Project, San Mateo County, CA, Treadwell & Rollo, September 23, 2008 ~~**(Appendix 4.3)**~~; and
10. Revised Geologic Evaluation, Environmental Impact Report, Highlands Estates Residential Development Report, San Mateo County, CA, Treadwell & Rollo, August 27, 2009 **(Appendix 4.3)**.~~.~~

In response to the Notice of Preparation (NOP) for this environmental impact report (EIR), several commenters expressed concern regarding geologic conditions at the site, including existing landslides and soil conditions. Several comments focused specifically on landslides and slope stability issues in the Bunker Hill Drive and Ticonderoga Drive areas. Concerns were also expressed about the ability of existing slopes to withstand earthquakes and the need for design recommendations to address the existing conditions. Commenters also expressed the need for sufficient stabilization measures for the proposed development to ensure the suitability of the site for construction. All of these scoping comments are addressed in the impact assessment presented below.

Additionally, a comment letter received from Cotton Shires & Associates, Inc., in response to the NOP, suggested that additional soil borings should be completed for the proposed residential lots located along Bunker Hill Drive to provide an adequate basis for the design of stabilization piers and foundations. The same comment letter also recommended the need for further site subsurface exploration for the residences proposed along Ticonderoga Drive. As a result, Treadwell & Rollo (geotechnical engineering firm retained by ~~San Mateo County~~Impact Sciences, Inc.) prepared additional cross-sections for the property and a quantitative slope stability analysis of the proposed site conditions based on the current design concept. They also conducted a peer review of all previous subsurface and geological investigations completed to date on the site.

During the public review of the December 2008 draft EIR, Cotton Shires and Associates, geologic and geotechnical consultants for the Highlands Community Association, submitted a Supplemental Geologic and Geotechnical Evaluation letter dated February 13, 2009, which is presented as an attachment in **Appendix 1.0**. This letter contained recommendations for further investigation to characterize the extent and depth of a landslide impacting the four lots (Lots 5 through 8) along Ticonderoga Drive and further analyses to develop a schematic buttress repair mitigation to be used to develop a grading plan. In addition, the letter recommended that additional studies be performed to evaluate: spring activity, stabilization piers, and historic landsliding for the Bunker Hill Drive lots; the potential for asbestos exposure from project grading; hydrology analyses and the potential for increased peak discharge to initiate debris flows or erosion; appropriate surface drainage control; evaluations of project slope stability under seismic ground shaking conditions; and an evaluation of the potential for adverse off-site impacts from the proposed project (improper drainage control that may result in shallow landsliding into adjacent developed property).

A project meeting was held on March 16, 2009, between Treadwell & Rollo, Cotton Shires and Associates, Impact Sciences, San Mateo County staff, including the County Geologist Ms. Jean Demouthe, and the project geotechnical consultant Cornerstone Earth Group. The purpose of this meeting was to discuss the geologic and geotechnical constraints in each of the four areas of development, and come to a consensus on what, if any, further studies should be performed as part of the EIR.

During that meeting, it was agreed upon by all parties to further evaluate the landslide impacting the Ticonderoga Drive lots by performing additional subsurface exploration in the area of the landslide, and conduct additional geologic mapping and evaluations for all of the four development areas, utilizing updated topographic surveys to be performed by BKF Engineers (the project surveyor and civil engineer).

Treadwell and Rollo has completed the scope of services agreed upon at the March 16, 2009 meeting, as described in the "Revised Geologic Evaluation" (dated August 27, 2009) in **Appendix 4.3**, which included all of the following activities:

- Performance of additional site reconnaissance and geologic mapping of all four development areas (the lots along Ticonderoga Drive, Bunker Hill Avenue, and at the ends of Cowpens Way and Cobblehill Place), utilizing the new topographic survey prepared by BKF Engineers. A separate site geologic map showing site geology, landslide limits, and any existing fill at each of the four areas was prepared and included in the revised geologic investigation report;

- Preparation of revised geologic cross-sections for each of the four development areas based on the updated topographic surveys;

- Additional consultation with Mr. Ted Sayre of Cotton Shires and Associates, Mr. Scott Fitinghoff of Cornerstone Earth Group, and Mr. Darwin Myers to review the updated maps and cross-sections. The consultants listed above mutually agreed on the locations for subsurface exploration within the Ticonderoga Drive lots;

- Excavation and down-hole logging of three hand-dug test pits excavated to depths between about 10 feet and 30 feet below the ground surface in the area of the landsliding impacting the Ticonderoga Drive lots. The excavated pits were left open for representatives from the Project Applicant's and Highlands Community Association's consulting firms to visit and observe the subsurface conditions and allow the project geotechnical consultant to obtain samples for future laboratory testing;

- Laboratory tests, consisting of Plasticity Index tests, Modified Proctor Tests, and shear tests of samples obtained from the test pits;

- Preparation of mitigation measures comparable to those discussed during the March 16, 2009 meeting, including development of a proposed schematic buttress fill plan and cross-section, showing the approximate depth and limits of grading to mitigate the landslide;

- Qualitative evaluation of the site hydrogeology characteristics and development of drainage recommendations as appropriate;

- Performance of static and pseudo-static (seismically loaded) quantitative slope stability analyses of the proposed buttress fill mitigation; and

- Preparation of a revised geologic investigation report, based on Treadwell and Rollo's prior study. This report was used to revise the draft EIR.

All of the issues raised by the Highlands Community Association are addressed in this updated section. Spring activity or groundwater is not expected to affect the site's stability because free groundwater or evidence of prior spring activity was not observed by Treadwell & Rollo during their field investigations.

As discussed later in this section, a buttress fill repair is recommended for the landslide on two of the Ticonderoga Drive lots; that repair solution eliminates the need for stabilization piers. Historic landsliding is not a concern for the Bunker Hill lots, as discussed under Impact GEO-1 below. The potential for asbestos exposure during project grading is addressed in **Subsection 4.4.2.4, Hazards and Hazardous Materials Impacts**. An evaluation of site hydrology, surface drainage control, and project slope stability under seismic ground shaking conditions is presented under Impact GEO-2 and an evaluation of the potential for adverse off-site impacts from the proposed project (landsliding into adjacent developed property) is addressed under Impact GEO-1.

~~This analysis is included in **Appendix 4.3** of this report. The Treadwell & Rollo report concluded that adequate information is available, based on all of the site explorations that have been completed to date (summarized below under **Project Site Geology**), to analyze the geology and soils impacts of the project according to the requirements of CEQA.~~

4.3.2 ENVIRONMENTAL SETTING

The sections below present a description of the environmental setting for the Highland Estates project site, concentrating on the portions of the project site proposed for development.

4.3.2.1 Regional Geology and Topography

The proposed project is located within the Coast Ranges Geomorphic Province on the San Francisco peninsula, a portion of the coast that includes a relatively narrow band of rock extending northwards from the Santa Cruz Mountains. This band separates the Pacific Ocean from the San Francisco Bay and represents one in a series of northwesterly-aligned mountain ranges that form the Coast Range Geomorphic Province of California.[1] The Franciscan Complex, an assemblage of Jurassic and Cretaceous-age rocks, dominates regional geology. As the Pacific Ocean crust was thrust under the North American Plate, the Franciscan Complex formed from oceanic rocks that were scraped from the subducting plate and blended into continental sediments derived from the North American Plate. Bedrock mapped in the area is primarily mélange (sheared rock), that typically consists of large and small assemblages of strong rock embedded in a fine-grained matrix of sheared and crushed shale. Sandstone and shale are the most common rock types found within the Franciscan Complex, but greenstone, serpentine, calcium-silicate rock, conglomerate, schist, and other metamorphic rocks can also be found.

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1 Geotechnical Investigation and Geologic Hazards Review of four single-family homes at Ticonderoga Drive, San Mateo, CA. Prepared by TRC Lowney. February 7, 2006

4.3.2.2 Regional Fault Systems

The Highland Estates project site is located at the western edge of the North American Tectonic Plate. This is an area of tectonic uplift related to movement along the San Andreas Fault system, which constitutes the boundary between the North American and Pacific Tectonic Plates. The northwest trending San Andreas Fault is the primary member of this fault system and lies approximately 1.3 km (0.8 mile) southwest of the project site. Tectonic motion between the Pacific and North American Tectonic Plates is accommodated not only along the main San Andreas trace, but also along other branch faults of the San Andreas Fault system, see **Figure 4.3-1, Regional Fault Map**.[2] The Calaveras and Hayward faults branch off the main trace of the San Andreas Fault, to the southeast of San Jose. No known active or potentially active faults are mapped that cross or project towards the project site, nor is the site located within a State designated fault zone.

Movement along the many splays of the San Andreas Fault system has produced the northwest trending topographic and structural trend that reflects the boundary between the North American and Pacific Tectonic Plates. The San Andreas Fault system is about 40 miles wide and extends from the San Gregorio fault at the coast to the Coast Ranges-Central Valley, blind thrust at the edge of the Great Central Valley. The San Andreas Fault system is the dominant fault in this region and is capable of producing the largest earthquakes, but many other faults in the system are also active and capable of producing earthquakes. Right lateral movement dominates on the fault zone, but thrust faulting from compression has also been observed.[3]

4.3.2.3 Regional Seismicity

Seismicity in the region is related to activity on the San Andreas Fault system. Movement is predominantly right lateral strike-slip.[4] The major active faults of the San Andreas Fault system, which are located less than 30 miles from the site and capable of producing a magnitude 7 or greater earthquake, are the San Andreas, San Gregorio, Calaveras, and Hayward faults. Several major historical earthquakes have shaken the region. In 1838 an estimated 7.5 Mw (moment magnitude) earthquake occurred on the central San Francisco Peninsula. An earthquake along the Hayward Fault in 1868 had an estimated Mw of 7.0. The famous San Francisco earthquake of 1906 that caused major damage had an estimated Mw of 7.9. Recently, the 1989 Loma Prieta Earthquake with a 6.9 Mw was centered on or near the San Andreas Fault, about 64 kilometers (40 miles) southwest of the site.

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2 TRC Lowney, 2006

3 TRC Lowney, 2006

4 For strike-slip faults, the rupture is nearly vertical and during an earthquake one side slides past the other. Association of Bay Area Government, http://www.abag.ca.gov/bayarea/eqmaps/fixit/ch2/sld003.html.

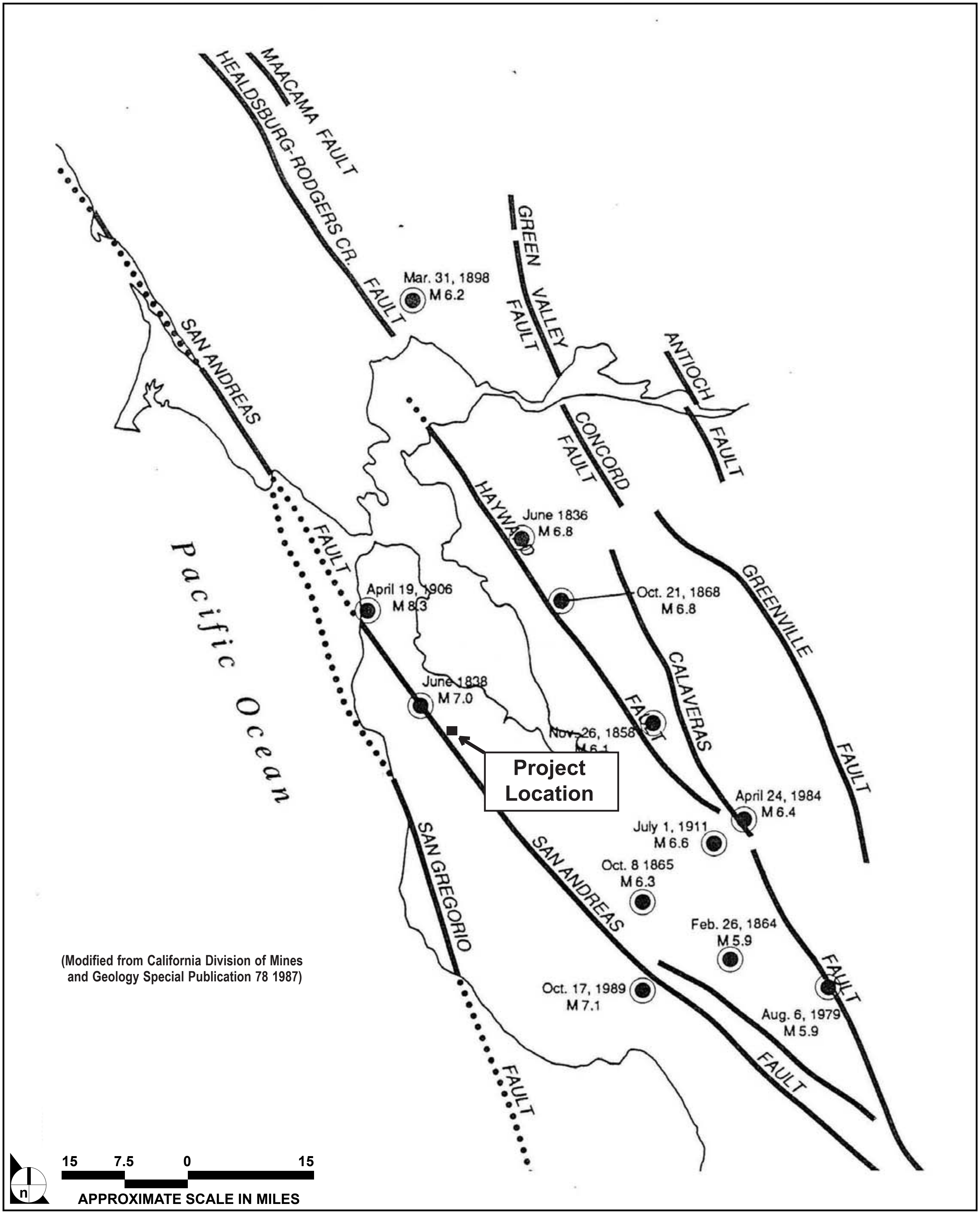
A fault with evidence of rupture during the past 11,000 years is considered an active seismic source. A fault with evidence of rupture during the Late Quaternary, the last 1.6 million years, but with unknown activity during the past 11,000 years is considered conditionally active. Faults are broadly classified by the CGS as being active during the Holocene (past 11,000 years), Late Quaternary (past 700,000 years), and the Quaternary (past 1.6 million years) periods. **Table 4.3-1, Active and Conditionally Active Faults within 50 miles of Highland Estates, San Mateo County, CA**, presents faults in the area that could potentially affect the proposed project. The maximum credible earthquake for the site is a Richter magnitude of 8.0 on the nearby San Andreas Fault.

Table 4.3-1
Active and Conditionally Active Faults within 50 miles of Highland Estates, San Mateo County, CA

Fault Name	Distance (mi/km)	Direction	Last Rupture	Classification	Mean Characteristic or Maximum Moment Magnitude [1]
San Andreas	0.8/1.3	SW	Historic	Active	7.90
Seal Cove	8/13	W	Holocene	Active	--
Monte Vista	14/23	SE	Late Quaternary	Conditionally Active	6.80
Hayward	17/28	NE	Historic	Active	6.91
San Gregorio	11/18	SW	Holocene	Active	7.44
Calaveras	25/41	E	Historic	Active	6.93
Pleasanton	28/45	NE	Holocene	Active	--
Concord	34/55	NE	Historic	Active	6.71
Las Positas	35/57	E	Historic	Active	--
Sargent	35/56	SE	Holocene	Active	6.80
Layton	36/58	NE	Holocene	Active	--
Marsh Creek	37/59	NE	Holocene	Active	--
Greenville	38/61	E	Historic	Active	6.94
Clayton	37/59	NE	Holocene	Active	--
Rogers Creek	45/73	N	Holocene	Active	6.98
Midway – San Joaquin	44/71	E	Late Quaternary	Conditionally Active	--

Source: Fault Activity Map of California and Adjacent Areas, 1994, California Department of Conservation, Division of Mines and Geology.

[1] *Probabilistic Seismic Hazard Assessment for the State of California, CGS Open-File Report 96-08, USGS Open-File Report 96-706.*



SOURCE: Questa Engineering Corporation - 2008

FIGURE **4.3-1**

Regional Fault Map

The USGS has assessed future earthquake probabilities along active faults in the Bay Area for the 30-year period from 2000 to 2030.[5] The Association of Bay Area Governments (ABAG) has adopted these probabilities as planning guides, as well as maps that show expected seismic shaking intensity for different earthquake scenarios that can be found online at the ABAG website. The 2007 Working Group on California Earthquake Probabilities calculated a 62 percent probability of a strong ($M \geq 6.7$) earthquake occurring on one of the faults of the San Francisco Bay area between the years 2007-2037.[6] They also calculated rupture probabilities for the individual faults in the region. These probabilities and 95 percent confidence bounds are presented as **Table 4.3-2, Fault Rupture Probabilities for the San Francisco Bay Area**.

Table 4.3-2
Fault Rupture Probabilities for the San Francisco Bay Area

Fault Name	Probability	95% Confidence Bounds
SF Bay Region	0.62	[0.41 to 0.84]
San Andreas	0.21	[0.06 to 0.39]
Hayward/Rogers Creek	0.31	[0.12 to 0.67]
Calaveras	0.07	[0.01 to 0.22]
Concord/Green Valley	0.11	[0.06 to 0.16]
San Gregorio	0.09	[0.04 to 0.12]
Greenville	0.05	[0.02 to 0.07]
Mount Diablo thrust	0.05	[0.03 to 0.07]
Background	0.14	[0.07 to 0.37]

Ground Shaking Hazard

Expected seismic shaking intensity and associated risk for individual structures depends upon the distance of the structure from the earthquake epicenter, the magnitude of the earthquake, the underlying geologic, groundwater, and soil conditions, and the type of construction. According to ABAG maps, violent shaking of the project site from a rupture of the San Andreas Fault would be experienced at an intensity of at least IX on the Modified Mercalli Intensity Scale (MMI). Implications of this rating are shown in **Table 4.3-3, Modified Mercalli Earthquake Intensity Scale**.

5 USGS 1999

6 2007 Working Group on California Earthquake Probabilities, Uniform California Earthquake Rupture Forecast, Version 2, 2008, obtained from http://pubs.usgs.gov/of/2007/1437/

Table 4.3-3
Modified Mercalli Earthquake Intensity Scale[7]

Scale	Intensity	Effects
I		Not felt.
II		Felt by persons at rest, on upper floors, or favorably placed.
III		Felt indoors. Hanging objects swing. Vibration like passing of light trucks.
IV		Hanging objects swing. Vibration like passing of heavy trucks. Standing motorcars rock. Windows, dishes, doors rattle. Glasses clink. Crockery clashes. In the upper range of IV, wooden walls and frame creak.
V	Light	Felt outdoors; direction estimated. Sleepers wakened. Liquids disturbed, some spilled. Small unstable objects displaced or upset. Doors swing, close, open. Shutters, pictures move. Pendulum clocks stop, start, change rate.
VI	Moderate	Felt by all. Many frightened and run outdoors. Persons walk unsteadily. Windows, dishes, glassware broken. Objects fall off shelves. Pictures off walls. Furniture moved or overturned. Weak plaster and poorly constructed or weak masonry cracked. Trees, bushes shaken (visibly, or heard to rustle).
VII	Strong	Difficult to stand. Noticed by drivers of motorcars. Hanging objects quiver. Furniture broken. Damage to poorly constructed or weak masonry. Weak chimneys broken at roofline. Fall of plaster, loose bricks, stones, tiles, and cornices. Some cracks in average unreinforced masonry. Waves on ponds; water turbid with mud. Small slides and caving in along sand or gravel banks. Large bells ring. Concrete irrigation ditches damaged
VIII	Very Strong	Steering of motorcars affected. Damage to average masonry and partial collapse. Some damage to reinforced masonry, but not to that specially designed for seismic loading. Fall of stucco and some masonry walls. Collapse of chimneys, factory stacks, monuments, towers, and elevated tanks. Frame houses moved on foundations if not bolted down; loose panel walls thrown out. Decayed piling broken off. Branches broken from trees. Changes in flow or temperature of springs and wells. Cracks in wet ground and on steep slopes.
IX	Violent	General panic. Poorly built or weak masonry destroyed; average unreinforced masonry heavily damaged, sometimes with complete collapse; reinforced masonry seriously damaged. (General damage to foundations.) Frame structures, if not bolted, shifted off foundations. Frames cracked. Serious damage to reservoirs. Underground pipes broken. Conspicuous cracks in ground. In alluvial areas sand and mud ejected, earthquake fountains, sand craters.
X	Very Violent	Most masonry and frame structures destroyed with their foundations. Some well-built wooden structures and bridges destroyed. Serious damage to dams, dikes, embankments. Large landslides. Water thrown on banks of canals, rivers, lakes, etc. Sand and mud shifted horizontally on beaches and flat land. Rails bent slightly.
XI	Very Violent	Rails bent greatly. Underground pipelines completely out of service.
XII	Very Violent	Damage nearly total. Large rock masses displaced. Lines of sight and level distorted. Objects thrown into the air.

7 Wood and Neumann, (1931), Modified Mercalli scale of 1931, *Bulletin of Seismological Society of America, 21, 277*-283.

4.3.2.4 Liquefaction Hazard and Ground Failure

Liquefaction is a phenomenon in which the strength and stiffness of unconsolidated sediments are reduced by earthquake shaking or other rapid loading. Poorly consolidated, water-saturated fine sands and silts having low plasticity and located within 50 feet of the ground surface are typically considered to be the most susceptible to liquefaction. Soils and sediments that are not water-saturated and that consist of coarser materials are generally less susceptible to liquefaction. Geologic age also influences the potential for liquefaction. Sediments deposited within the past few thousand years are generally much more susceptible to liquefaction than older Holocene sediments; Pleistocene sediments are even more resistant; and pre-Pleistocene sediments are generally immune to liquefaction.[8]

Two potential ground failure types associated with liquefaction are lateral spreading and differential settlement.[9] Lateral spreading involves a layer of ground at the surface being carried on an underlying layer of liquefied material over a nearly level surface toward a river channel or other open face. Differential settlement occurs when the layers that liquefy are not of uniform thickness, a common problem when the liquefaction occurs in artificial fills.

4.3.2.5 Project Site Geology[10]

The project site has been the subject of a number of geotechnical investigations over the past few decades. For many of the investigations completed in the past, the configuration of the proposed project has varied, proposing residential units in different areas and/or alignments. However, the combined geotechnical investigations conducted in the past and present have explored the entirety of the currently proposed project area. Multiple soil borings and cross-sections were completed within the lots proposed for development. This recirculated draft EIR includes information from historic and recent geotechnical studies, supplemental to the information analyzed in the Initial Study for this project. A graphic illustrating the location of all of the subsurface explorations conducted is shown in **Figure 4.3-2, ~~Project Site~~ Bunker Hill Drive Boring Locations, Figure 4.3-3, Ticonderoga Drive Boring Locations, Figure 4.3-4, Cobblehill Place Boring Locations, and Figure 4.3-54, Cowpens Way Boring Locations**. A summary of the investigations included in this analysis is provided below.

8 California Department of Conservation, Division of Mines and Geology, 1997.

9 Association of Bay Area Governments, 2001.

10 Revised Geologic Evaluation, Environmental Impact Report, ~~for~~ Highlands Estates Residential Development Project, San Mateo, CA, Treadwell & Rollo, ~~2008~~2009.

Summary of Geotechnical Investigations

United Soil Engineering – 1977

United Soil Engineering performed a study for lots formerly proposed on Ticonderoga Drive and Cobblehill Place. The subsurface investigation included nine borings drilled to depths of 8 to 21.5 feet, shown in **Figure 4.3-2** as borings performed by Berlogar, Long, and Associates. The borings encountered Franciscan Complex sandstone and shale.

Soil Foundation Systems – 1990

Soil Foundation Systems (SFS) performed an investigation for lots formerly proposed in the area that corresponds to the proposed project site along Bunker Hill Drive, as well as the previously proposed town homes off Polhemus Road. The subsurface investigation included six borings drilled to a maximum depth of 30 feet. The borings encountered shale and greywacke sandstone.

Soil Foundation Systems – 1993

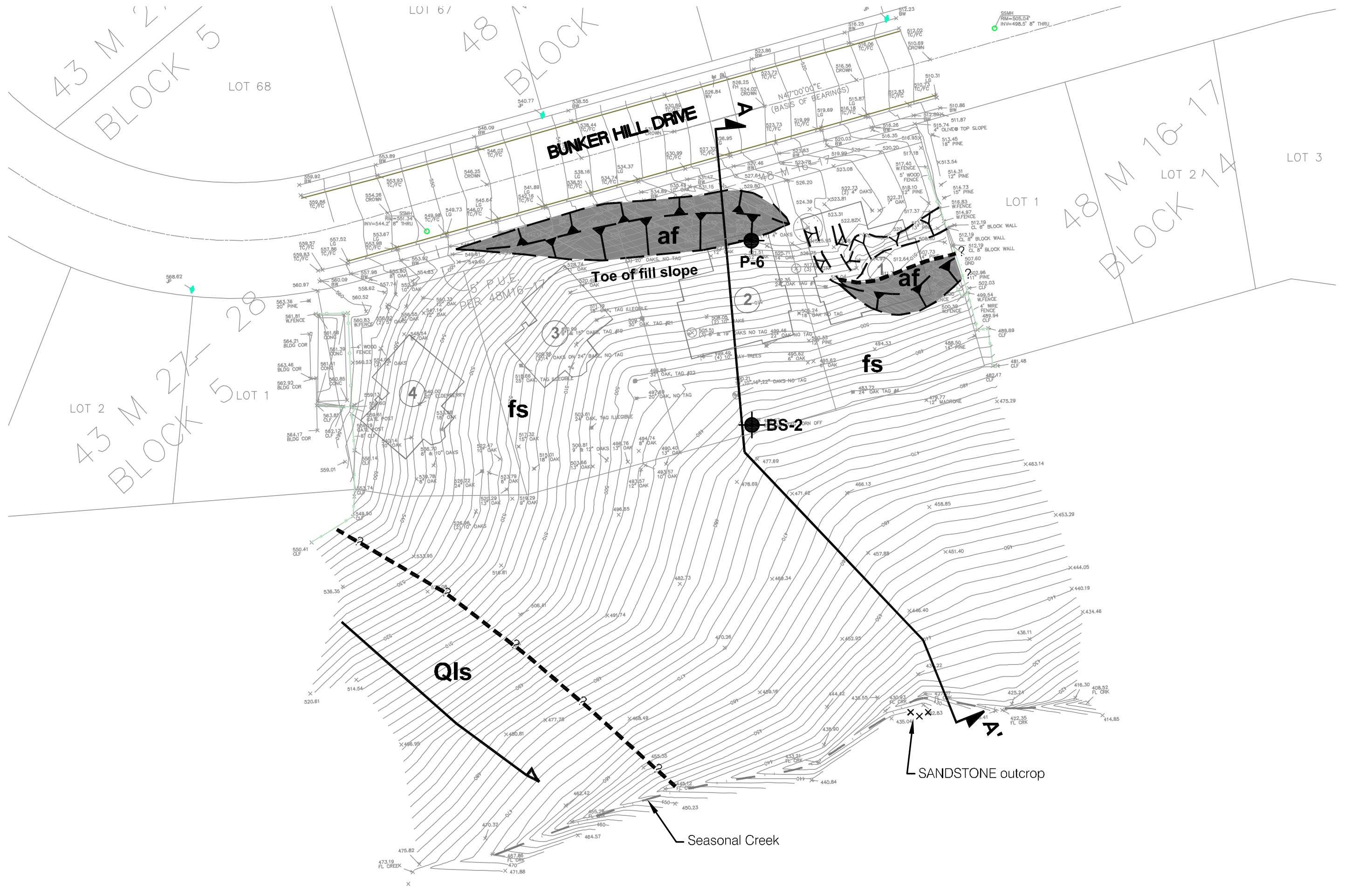
In 1993, SFS performed another investigation for lots formerly proposed in the area that corresponds to the proposed project site along Bunker Hill Drive, Lots 1 through 18, as well as the previously proposed town homes off Polhemus Road. The subsurface investigation included 26 borings to depths of up to 42 feet, and 3 test pits up to depths of 16 feet. They performed engineering and geologic analyses, and prepared 10 geologic cross sections. The investigation included performing static and pseudo-static slope stability analyses on 10 cross sections generated through the site.

Earth Systems Consultants – 1993

ESC performed a geotechnical review of the 1993 report by SFS. Their review comments were generally minor, consisting mainly of pointing out errors in boring logs and cross sections.

Lowney and Associates – 1993

Lowney and Associates performed a review of the slope stability analyses performed by SFS in their 1993 report. After performing their own stability analyses, they concluded that the SFS methods and results were consistent with the current standards of practice at the time.



EXPLANATION

- **P-6** — Approximate location of boring by Soil Foundation systems, 1990
- **BS-2** — Approximate location of boring by Soil Foundation Systems, 1993
- **A — A'** — Idealized subsurface profile
- **af** — Artificial fill
- **fs** — Franciscan sandstone
- **Qls** — Landslide
- Cut slope
- Fill slope
- Direction of landslide
- Sandstone outcrop
- (1) Proposed lot number

60 30 0 60

APPROXIMATE SCALE IN FEET

Reference: Base map from a site plan titled "Highland Estates - Ticonderoga, Partial Topopgrahic Survey, by BKF, dated 05/13/09.

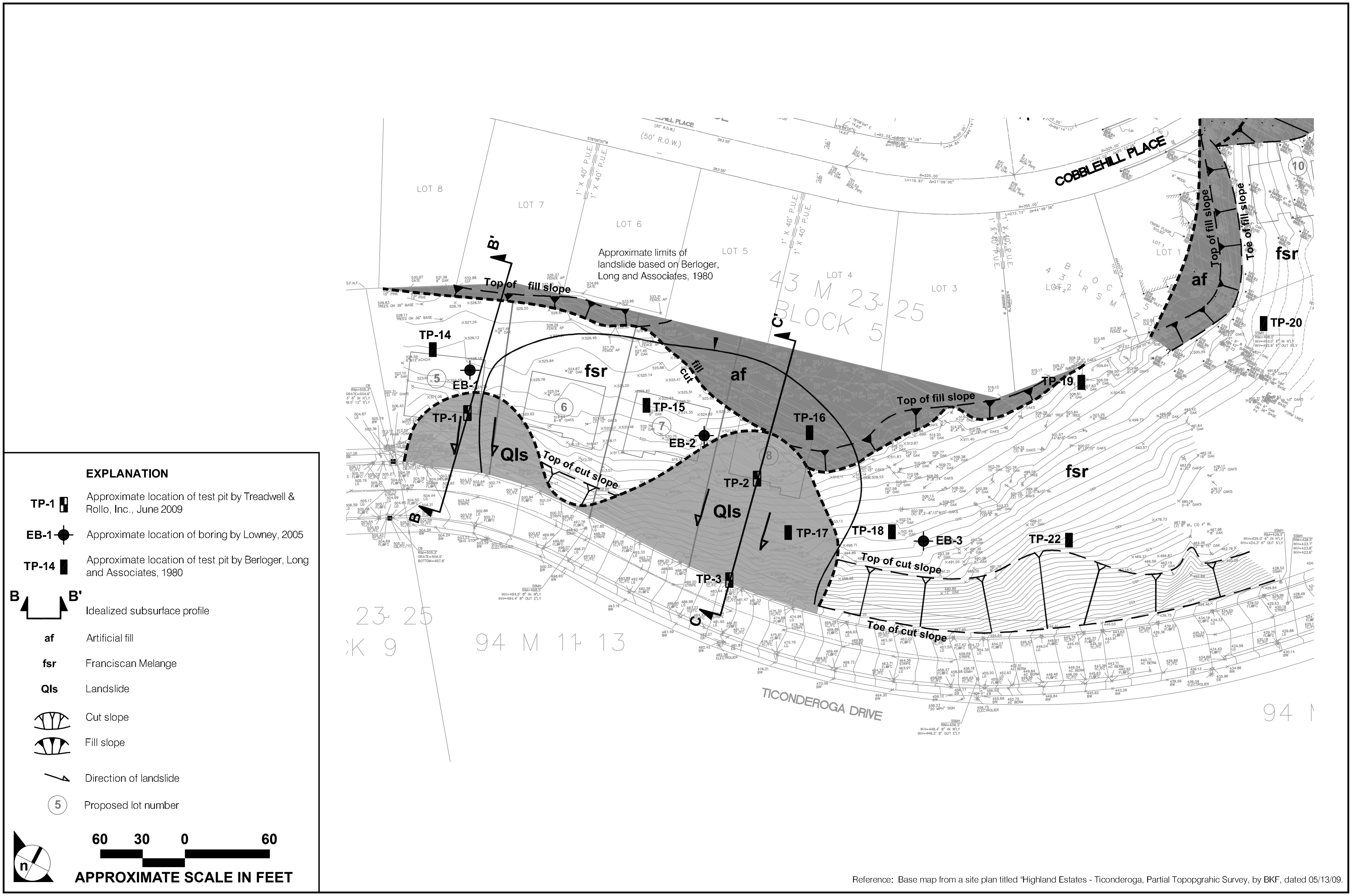
SOURCE: Treadwell & Rollo - August 2009

FIGURE **4.3-2**

Bunker Hill Drive Boring Locations

902-001•08/09

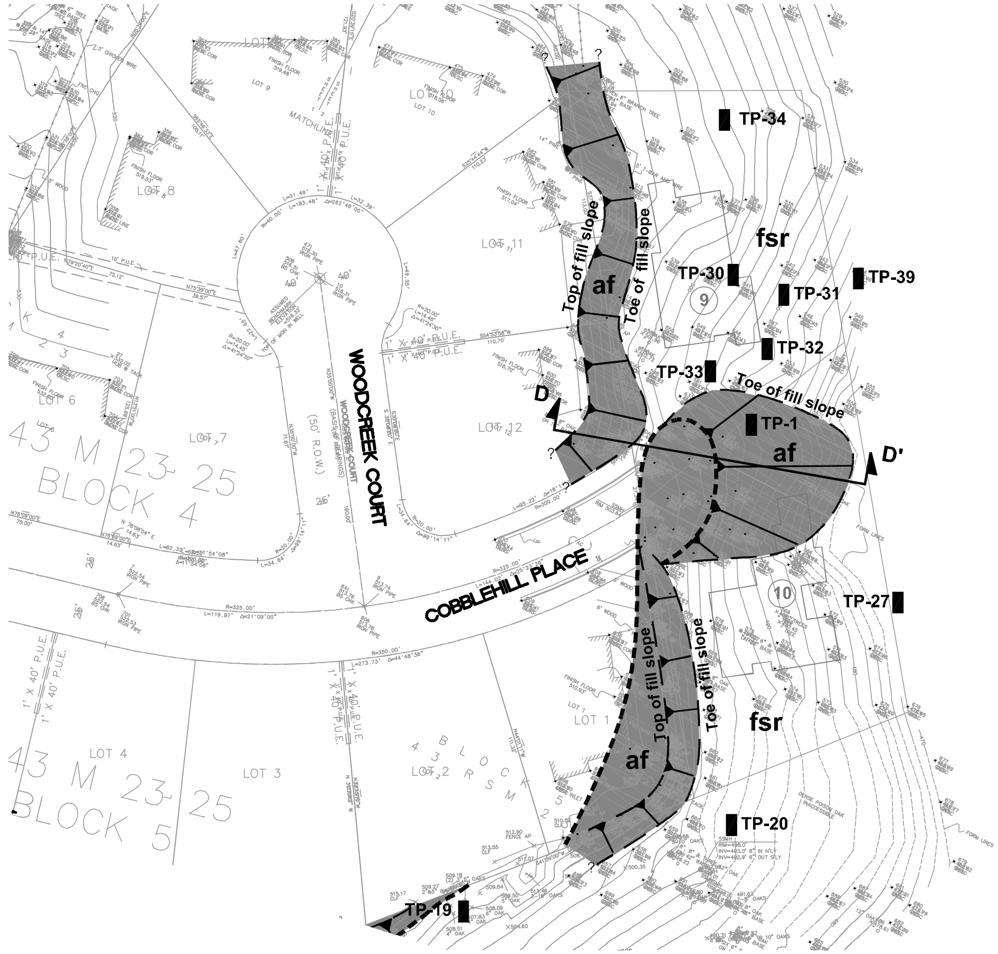
R:\Trgraphics\4800's\4872.02\4872.02 Site Plan and Engineering Geo Map.dwg 8/27/09



SOURCE: Treadwell & Rollo - August 2009

FIGURE **4.3-3**

Ticonderoga Drive Boring Locations



EXPLANATION

TP-19 ▌ Approximate location of test pit by Berloger, Long and Associates, 1980

D D' Idealized subsurface profile

af Artificial fill

fsr Franciscan Melange

Qls Landslide

Cut slope

Fill slope

Direction of landslide

(9) Proposed lot number

60 30 0 60

APPROXIMATE SCALE IN FEET

Reference: Base map from a site plan titled "Highland Estates - Ticonderoga, Partial Topopgrahic Survey, by BKF, dated 05/13/09.

SOURCE: Treadwell & Rollo - August 2009

FIGURE **4.3-4**

Cobblehill Place Boring Locations

902-001•08/09

R:\Trgraphics\4800's\4872.02\4872.02 Site Plan and Engineering Geo Map.dwg 8/27/09

SOURCE: Treadwell & Rollo - August 2009

FIGURE **4.3-5**

Cowpens Way Boring Locations

Soil Foundation Systems – 1994

After Earth Systems Consultants (ESC) and Lowney and Associates presented their review comments of the SFS 1993 report, SFS issued a supplemental report in 1994. Their supplemental work included two additional borings and three test pits in areas recommended by ESC during their review. They also conducted additional lab testing and performed several additional slope stability analyses, utilizing a higher seismic coefficient. In addition to responding to the comments by ESC and Lowney and Associates, they included a report by Tensar Earth Technologies, Inc. containing additional modeling and stability analyses of proposed Geogrid reinforced buttress fills.

TRC Lowney – 2006

TRC Lowney performed a geotechnical investigation and geologic hazards review for the area that now constitutes lots 5 through 8 on Ticonderoga Drive at the project site. Their investigation included three test borings to a maximum depth of 20 feet. They performed laboratory testing and prepared four geologic cross sections summarizing the subsurface data.

Treadwell & Rollo – 2008

Treadwell and Rollo were retained by ~~San Mateo County~~Impact Sciences, Inc., to prepare a geologic evaluation report for the project site. Their investigation included a review of prior geologic and geotechnical investigations performed for the site, a review of aerial photographs and geologic literature, and a site reconnaissance. As part of their investigation, they generated five geologic cross sections across the site. ~~Locations of cross sections are shown in **Figure 24.3-2**, with drawings located in **Appendix 4.3**. The report concluded that the currently proposed residential developments are feasible from a geologic perspective.~~

Treadwell & Rollo – 2009

Treadwell and Rollo revised the geologic evaluation report prepared for the project site in 2008. To augment the existing subsurface information and further evaluate subsurface conditions within the lots along Ticonderoga Drive that are impacted by landsliding, they performed a subsurface exploration program consisting of excavating and down-hole logging three test pits, designated TP-1 through TP-3. The approximate locations of the borings and test pits are shown in **Figures 4.3-2** through **4.3-5,** with drawings presented in **Appendix 4.3**.

Soils

Based on the borehole logs from geotechnical investigations performed by SFS, native soils form the surface materials on lots 1-7, whereas on lots 8, 9, 10, and 11 the surface materials consist of deposited fill. This fill consists of dark brown to black clayey silt and silty clay soils, with gravel inclusions of serpentine and sandstone.

Existing Fill

As described above, the project site contains existing fill, which consists of man-made deposits of unconsolidated material with a broad range of composition. The largest deposits are located in the central portion of the site, adjacent to the existing homes along Yorktown Road, while small amounts of fill are also present along the upper western portion of the site, which borders existing residential homes. Based on the soil borings completed by SFS and TRC Lowney, the deepest fill soils found on a development parcel are located in the rear of lot 8 on Ticonderoga Drive. Approximately 10 feet of fill is located on lot 8, likely related to construction of houses along Cobblehill Place. There are also ~~minor~~ moderate amounts of fill located under the western portions of lots 9 and 10, likely related to construction of the cul-de-sac at the end of Cobblehill Place. Additionally, up to approximately ~~four~~ six to seven feet of fill underlies the western half of lot 11, likely related to construction of Cowpens Way.

Alluvium

Unconsolidated stream deposits of brown gravelly sand with clay are present at the site along the three main drainages. Alluvial deposits are mapped in the open space portion of the site, downslope from lots 9-11, but are not found on any development parcels. Deposits appear to be derived from Franciscan assemblage rocks typical of the area. The thickness of alluvial deposits encountered in soil borings drilled in the southernmost main drainage ranged from approximately 10 to 22 feet. Severely weathered greywacke sandstone bedrock was encountered below the alluvial deposits.

Colluvium

Colluvial deposits were also encountered in soil borings on the site. Colluvium generally consists of unconsolidated clay, silt, sand, and gravel derived from the weathering of bedrock materials and deposited by slow slope processes on hillslopes and in swales. Colluvium is generally thickest in swale axes. Colluvial deposits encountered in soil borings were generally thicker in the southern portion of the site, but rarely exceeded 10 feet.

Landslide Deposits

Landslide deposits were mapped on the project site by SFS in the area of currently proposed lots 5 through 8, along Ticonderoga Drive. The landslide deposits found included soil slips, earthflows, and earthflow complexes. During the Treadwell & Rollo field reconnaissancetheir 2009 supplemental field mapping and investigation, Treadwell & Rollo determined that the area is in fact affected by two separate landslides. The landslide areas, this landslide was observed to beare characterized by hummocky topography and an oversteepened head scarps, of approximately seven two to eight feet in height.

Treadwell & Rollo mapped the limits of this landslide based on surficial expressions, as shown on Figure 2 of their report. In addition, a large landslide was also mapped by SFS, on the opposite side of the slope west of the subject lots above the drainage that runs along the south side of lots 1 through 4 on Bunker Hill Drive. Based on the current site configuration and mapping of this landslide by SFS, Based on site observations during their supplemental field investigation, Treadwell & Rollo concluded that the this landslide along Bunker Hill Drive was relatively shallow and constrained to the colluvium and top soil mantling the bedrock in this area, and the geometry of the landslide indicates the slide would not impact proposed development on lots 1-4. They did not observe any landsliding within lots 1 through 4 or directly downslope of these lots. Landslides for particular proposed lots are discussed in further detail below under **Subsection Proposed Lot Conditions.**

Bedrock

Franciscan Mélange

The site is underlain by Franciscan Mélange of Jurassic to Cretaceous age. This unit consists of a tectonic mixture of small to large resistant blocks of various rock types, including greywacke sandstone, greenstone, chert, and serpentine within a sheared matrix of greywacke and shale. Bedrock at the site ranges from intensely fractured to crushed, and may be highly altered due to the long history of shearing in the Coast Range and close proximity to the San Andreas Fault zone. The site contains two large coherent masses of greywacke sandstone and serpentine within the sheared matrix. The blocks of competent rock within the weaker, sheared matrix tend to have high strength characteristics. Locally the matrix is easily eroded where exposed to weathering.

Drainage

Natural drainage for most of the site occurs through overland flow and shallow subsurface flow into the three main drainages and subsidiary swales, which drain toward Polhemus Creek to the northeast. The northernmost drainage descends eastward from Yorktown Road and parallels Bunker Hill Drive. The middle drainage descends eastward from Lexington Avenue to Bunker Hill Drive. The southernmost drainage descends eastward from Cowpens Way and Brunswick Drive to Polhemus Road, through the Hillsborough West Apartments. Natural drainage of the west-sloping portion of the site occurs through overland sheet flow into existing drainage ditches and storm sewers.

Topography

The site is located on the northeast slopes of Pulgas Ridge, a northwest trending ridge east of Crystal Springs Reservoir and west of Polhemus Creek. Several spur ridges with intervening swales roughly northeast-trending descend from the main ridge towards Polhemus Creek, northeast of the site. Elevations on the site range from 350 to 750 feet above mean sea level. Slopes in areas proposed for development range from 0 to 50 percent. Natural landforms on the project site appear to have been modified in the area adjacent to existing residences and along abandoned dirt roads within the site. Modifications include cuts and fills in the northwestern portion of the site, localized grading on hill slopes immediately south and west of the Hillsborough West apartments, cuts along the northern side of Ticonderoga Drive between Polhemus Road and Allegheny Way in the southern portion of the site, and the placement of fill in areas along the upper, western elevations of the site.

Proposed Lot Conditions[11]

Lots 1 through 4

These lots are proposed on a southeast-facing slope on the south side of Bunker Hill Drive. The lots would be bordered to the northwest by Bunker Hill Drive, to the southeast by a natural drainage course and undeveloped slope, and to the northeast and southwest by developed residential parcels. The existing slope for these lots is moderately steep to very steep (~~1.5:1 to 2.5:1~~2:1 to 3:1, horizontal to vertical). Graywacke sandstone is present in the creek at the bottom of the drainage course.

A fill berm parallels Bunker Hill Drive~~ and there appears to be a possible fill pad in lot 1~~, on top of which there are fill desiccation cracks. The fill covers an area up to about 30 feet wide by 170 feet long along the front of Lots 2 and 3, and is up to about 3 to 4 feet thick. Additional minor grading has been performed in Lot 1, resulting in a small roughly level fill pad and small cut slopes up to about 5 to 6 feet in height. Sandstone bedrock is exposed at the base of the larger cut slope.

Borings in this area found up to 2 to 3 feet of colluvium mantling the greywacke sandstone bedrock. Drainage in this area is characterized by uncontrolled sheet flow to the southeast.

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11 Treadwell & Rollo, 2008 and 2009.

Lots 5 through 8

These lots would be located on a south-facing slope on the north side of Ticonderoga Drive. Slopes in this area are moderately steep (2:1 to 2.5:1, horizontal to vertical), and the area is dominated by a broad, gently sloping area in the northern portion, then a steep cut-slope down to Ticonderoga Drive that appears to have been cut during the initial grading of the road. Minor amounts of fill are scattered along the northern portion of the sites, particularly along the property boundary where fill placed for the development of the backyard areas of the lots on Cobblehill Place extends onto these lots. Sandstone is present in the road cuts and in scattered outcrops on the lots. As noted above, ~~A~~ two separate landslides ~~was~~ were identified in this area along Ticonderoga Drive. The first one is a small landslide that is a shallow failure of the cutslope on the uphill side of Ticonderoga Drive in the southern portion of lots 5 and 6. The landslide is approximately 95 feet wide, about 55 feet long and about 7 feet deep and appears to toe out in the slope above Ticonderoga Drive. The second landslide is a much larger slide occupying portions of lots 7 and 8 and is approximately 160 feet wide, about 105 feet long and about 26 feet deep. This landslide extends beneath Ticonderoga Drive at a depth of 6 to 7 feet below ground surface. Site drainage for these lots is characterized by uncontrolled sheet flow down to the south onto Ticonderoga Drive and as concentrated runoff in drainage rills.

Lots 9 and 10

These lots would be located at the end of Cobblehill Place. The proposed housing sites are gently to steeply sloping, running along the crest of a ridge at the head of a major east-trending drainage swale. This area is underlain by massive sandstone, with minor fill located in the western portions of the site from previous grading for Cobblehill Place and the two adjacent residences. In addition, undocumented fill is located in the central southwestern portion of the site, creating a relatively level fill pad as an extension of the end of Cobblehill Place. A moderately steep fill slope with a gradient of between about 2:1 and 3:1 extends to the north, northeast, and east below this pad. Based on prior borings, this fill appears to be about 6 to 7 feet thick. The proposed driveway for both residences crosses the fill pad, and a portion of the proposed residence for Lot 10 extends into the fill slope. Site drainage in this area is characterized by uncontrolled sheet flow down into the east-trending swale. Additionally, runoff from Cobblehill Place has resulted in minor erosion scars up to approximately one foot deep across the property.

Lot 11

This lot would be located at the end of Cowpens Way. The southwestern portion of this area is relatively flat, with a slope extending down to the northeast in the northeastern portion of the site. This area was created by the placement of a wedge of fill, up to about 6 to 7 feet thick. There is also fill along the southwest property boundary from grading performed to create the pads for the two adjacent residences. Sandstone and serpentine boulders outcrop in the northwestern portion of the site, and a small sliver of fill exists along the southwest property boundary. Site drainage in this area is characterized by uncontrolled sheet flow to the northeast.

Landslides

Natural and man-made slopes on the site and within the project vicinity have been subject to various forms of slope instability in recent years. A landslide susceptibility map completed for San Mateo County by the USGS identifies the site within an area classified as zone III - moderately susceptible to landslides. Zone III includes areas with slopes generally greater than 30 percent, but includes some slopes of 15 percent to 30 percent in areas underlain by unstable bedrock units. In general, zone III areas are characterized by many small landslides and may include some large landslides. Since the overall project is planned on a site with moderate to steep slopes near the crest of Pulgas Ridge, which is underlain by sheared rocks of the Franciscan formation, the potential for landslides is low in the coherent bedrock material and moderate to high in the landslide deposit areas. Existing shallow slope failures are deemed to be the result of slope over-steepening associated with the construction of Ticonderoga Drive.[12]

The USGS map shows slope stability in the area during earthquakes. The map shows lots 5–11 along Ticonderoga Drive, Cobblehill Place, and Cowpens Way as located in an area that is moderately to highly susceptible to seismic landslides. This means that 15 to 25 percent of the land is likely to fail during a major earthquake. Lots 1–4 along Bunker Hill Drive are in an area mapped as having a low susceptibility (approximately 3 percent) to seismic landslides. Most of lot 9 is mapped as highly susceptible to seismic landslides.[13] The following existing landslide deposits were mapped in the area.

- The area at the head of the northernmost drainage shows a moderately sized (approximately 300 ft wide) landslide south of lot 4.
- A series of small to moderately sized landslides are mapped within the middle drainage north of the intersection of Lexington Avenue and Ticonderoga Drive.
- A small landslide is mapped southwest of where Bunker Hill Drive meets Polhemus Drive.

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12 Geotechnical Investigation and Geologic Hazards Review of four single-family homes at Ticonderoga Drive, San Mateo, CA. Prepared by TRC Lowney. February 7, 2006

13 Wieczorek, Gerald, Map Showing Slope Stability During Earthquakes in San Mateo County, CA, United States Geological Survey, 1985

- A small to moderately sized landslide with deposits covering lots 6, 7, and part of lot 5 is mapped.[14]

The Treadwell & Rollo Report also analyzed aerial photographs of the site taken between the years 1943 and 2005. The report noted what appeared to be an old landslide trending south-north, located approximately 130 feet southeast of the center of the smallest California Water Company tank, within the proposed open space area. Areas of groundwater seepage were also noted in proposed lots 5 through 8, in the areas previously identified by SFS as a landslide.

4.3.3 REGULATORY CONSIDERATIONS

4.3.3.1 Federal Regulations

Disaster Mitigation Act of 2000

On October 30, 2000, the Disaster Mitigation Act (DMA) of 2000 was signed into law (Public Law 106-390). DMA 2000 amended the Robert T. Stafford Disaster Relief and Emergency Assistance Act by repealing the previous mitigation planning provisions (Section 409) and replacing them with a new set of requirements (Section 322). The new law emphasizes the need for state, tribal, and local entities to coordinate disaster mitigation planning and implementation efforts closely.

Section 322 continues the requirement for a State mitigation plan as a condition of disaster assistance, adding incentives for increased coordination and integration of mitigation activities at the State level through the establishment of requirements for two different levels of state plans: Standard and Enhanced. States that demonstrate an increased commitment to comprehensive mitigation planning and implementation through the development of an approved Enhanced State Plan can increase the amount of funding available through the Hazard Mitigation Grant Program (HMGP). Section 322 also established a new requirement for local mitigation plans and authorized up to 7 percent of HMGP funds available to a state to be used for development of state, tribal, and local mitigation plans.

Provisions of the DMA 2000 include:

- Funding for disaster planning and mitigation;
- Development of experimental multi-hazard maps to better understand risk;
- Establishment of state and local government infrastructure mitigation planning requirements (Advance Infrastructure Mitigation [AIM]);

[14] As noted earlier, Treadwell & Rollo's investigation showed that instead of one landslide, there are two separate landslides affecting portions of lots 5 through 8.

- Defining how states can assume more responsibility in managing the Hazard Mitigation Grant Program (HMGP);
- Adjusting ways in which management costs for projects are funded; and
- Establishment of performance-based standards for mitigation plans and require states to have a program (AIM) to develop county government plans. Should counties fail to develop an infrastructure mitigation plan, their federal share of damage assistance would be reduced from 75 percent to 25 percent if there were recurrent damage to the same facility or structure in response to the same type of disaster.

In order to maintain compliance with DMA 2000 and receive full federal funding, the Association of Bay Area Governments (ABAG) received funds from the Federal Emergency Management Agency (FEMA) to serve as the lead agency in the creation of a Local Hazard Mitigation Plan for the nine-county San Francisco Bay Area. With participation from Bay Area cities, ABAG produced an umbrella Hazard Mitigation Plan entitled "Taming Natural Disasters."[15]

4.3.3.2 State Regulations

Alquist-Priolo Earthquake Fault Zoning Act

The California Legislature passed the Alquist-Priolo Earthquake Fault Zoning Act in 1972 to mitigate the hazard to structures from surface faulting. The Act's main purpose is to prevent the construction of buildings used for human occupancy on the surface trace of active faults. The Act addresses only the hazard of surface fault rupture and is not directed toward other earthquake hazards. Local agencies must regulate most development in fault zones established by the State Geologist.

California Seismic Hazards Mapping Act

The California Seismic Hazards Mapping Act of 1990 (California Public Resources Code Sections 2690-2699.6) addresses seismic hazards other than surface rupture, such as liquefaction and seismically induced landslides. The Seismic Hazards Mapping Act specifies that the lead agency for a project may withhold development permits until geologic or soils investigations are conducted for specific sites and mitigation measures are incorporated into plans to reduce hazards associated with seismicity and unstable soils.

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15 Association of Bay Area Governments Multi-Jurisdictional Local Hazard Mitigation Plan obtained from http://quake.abag.ca.gov/mitigation/plan.html

California Building Code

Title 24 of the California Code of Regulations, also known as the California Building Standards Code, sets minimum requirements for building design and construction. The 2007 version of the California Building Standards Code is effective as of January 1, 2008. In the context of earthquake hazards, the California Building Standards Code's design standards have a primary objective of assuring public safety and a secondary goal of minimizing property damage and maintaining function during and following seismic events. The 2007 version of the California Building Standards Code differs significantly from the previous versions of the code. The 2007 code assigns a seismic design category (SDC) to each structure. The SDC is assigned as a means of capturing both the seismic hazard, in terms of mapped acceleration parameters (spectral values), site class (defining the soil profile), and the occupancy category (based on its importance or hazardous material contents). The SDC affects design and detailing requirements as well as the structural system that may be used and its height. The previous versions of the code captured these requirements simply based on the location's seismic zone.[16]

San Francisco Bay Regional Water Quality Control Board

The proposed project will require coverage under the statewide General Permit for discharge associated with construction activities pursuant to National Pollution Discharge Elimination System (NPDES) requirements. A storm water pollution prevention plan shall be prepared along with a grading plan to fulfill the requirements of the State of California General Permit.

4.3.3.3 Local Laws, Regulations, and Policies

Association of Bay Area Governments Hazard Mitigation Plan

ABAG is a regional planning agency for the nine-county San Francisco bay area, of which San Mateo is a member. As noted above, ABAG has developed a hazard mitigation plan with appendices for local governments. Nine hazards are identified by ABAG, five related to earthquakes (faulting, shaking seismically induced landslides, liquefaction, and tsunamis), and four related to weather (flooding, landslides, fire, and drought). The plan identifies policies and actions that may be implemented by the County to reduce the potential for loss of life and property damage in these areas based on an analysis of natural hazards in terms of frequency, intensity, location, history, and damage effects. The plan serves as a guide for decision-makers as they commit resources to reduce the effects of natural hazards.

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16 Bonneville, David. New Building Code Provisions and Their Implications for Design and Construction in California (abstract), 2007, obtained from http://www.consrv.ca.gov/cgs/smip/docs/seminar/SMIP07/Pages/Paper12_Bonneville.aspx

San Mateo County General Plan

The County of San Mateo General Plan, adopted November 1986, is designed to identify natural hazards such as earthquakes, floods, wildland fires, and other natural hazards. This plan includes a natural hazards element, which analyzes impacts of natural hazards. The plan identifies policies and actions that may be implemented by the County to reduce the potential for loss of life and property damage based on an analysis of earthquakes, floods, wildland fires, and landslides in terms of frequency, intensity, location, history, and damage effects. The Plan serves as a guide for decision-makers as they commit resources to reduce the effects of natural hazards.

Applicable General Plan Policies

Policy 15.20-b

Whenever possible, avoid construction in steeply (>30 percent) sloping areas.

Policy 15.20-d

In extraordinary circumstances when there are no alternative building sites available, allow development in geotechnically hazardous and/or steeply sloping areas when appropriate structural design measures to ensure safety and reduce hazardous conditions to an acceptable level are incorporated into the project.

Policy 15.21-a

In order to more precisely define the scope of the geotechnical hazards, the appropriate locations for structures on a specific site and suitable mitigation measures, require an adequate geotechnical investigation for public or private development proposals located: (1) in an Alquist-Priolo Special Studies Zone, or (2) in any other area of the County where an investigation is deemed necessary by the County Department of Public Works.

San Mateo County Zoning Regulations

The San Mateo County zoning regulations, adopted in 1999, were designed by the County to help guide the physical development of land and future growth within the County. The following sections of the zoning regulations would apply to the proposed project.

SECTION 6324.2. Site Design Criteria

(b) All roads, buildings and other structural improvements or land coverage shall be located, sited, and designed to fit the natural topography and shall minimize grading and modification of existing land forms and natural characteristics. Primary Designated Landscape Features defined in the Open Space and Conservation Elements of the San Mateo County General Plan shall not be damaged.

(f) The applicant shall demonstrate that the development will not contribute to the instability of the parcel or adjoining lands and that all structural proposals including excavation, and proposed roads and other pavement have adequately compensated for adverse soil engineering characteristics and other subsurface conditions.

SECTION 6324.6. Hazards to Public Safety Criteria

(a) Reasonable and appropriate setbacks from hazardous areas shall be provided within hazardous areas defined within the Conservation, Open Space, Safety and Seismic Safety Elements of the San Mateo County General Plan.

(c) Notwithstanding the permitted development density under this Ordinance, areas shall not be used for placement of structures: 1) which are severely hazardous to life and property due to soils, geological, seismic, hydrological, or fire factors; 2) whose development would pose a severe hazard to persons or property outside the proposed development; or 3) for which elimination of such hazards would require major modification of existing land forms, significant removal or potential damage to established trees or exposure of slopes which cannot be suitably revegetated.

(f) No land shall be developed which is held unsuitable by the Planning Commission for its proposed use for reason of exposure to fire, flooding, inadequate drainage, soil and rock formations with severe limitations for development, susceptibility to mudslides or earthslides, severe erosion potential, steep slopes, inadequate water supply or sewage disposal capabilities, or any other feature harmful to the health, safety or welfare of the future residents or property owners of the proposed development or the community-at-large. To determine the appropriateness of development the following shall be considered:

1. The danger to life and property due to the designated hazards caused by excavation, fill, roads, and intended uses.

2. The danger that structures or other improvements may slide or be swept onto other lands or downstream to the injury of others.

3. The adequacy of proposed water supply and sanitation systems, and the ability of those systems to prevent disease, contamination and unsanitary conditions during or following a hazardous event or condition.

4. The susceptibility of the proposed facility and its contents to potential damage, and the effect of such damage to the property.

5. The importance of the services provided by the proposed facility to the community.

6. The availability of a sufficient amount of water, as defined by the fire protection agency, for fire suppression purposes.

7. The availability of alternative locations, not subject to hazards.

8. The relationship of the proposed development to the Safety, Seismic Safety, and Open Space and Conservation Elements of the San Mateo County General Plan.

4.3.4 CONSISTENCY WITH APPLICABLE REGULATIONS

CEQA requires an analysis of consistency with plans and policies as part of the environmental setting (*State CEQA Guidelines* Section 15125). The General Plan Guidelines published by the State Office of Planning and Research define consistency as follows: "An action, program, or project is consistent with the General Plan if, considering all its aspects, it will further the objectives and policies of the General Plan and not obstruct their attainment." Therefore, the standard for analysis used in the EIR is based on general agreement with the policy language and furtherance of the policy intent (as determined by a review of the policy context). The project does not have to be in exact agreement with a policy for a project to be consistent with it.

4.3.4.1 County of San Mateo General Plan and Zoning Regulations

The proposed project would comply with the applicable Site Design Criteria and Hazards to Public Safety Criteria for the RM District. With the implementation of mitigation measures, the development will not contribute to the instability of the parcel or adjoining lands and the project will be designed to adequately compensate for adverse soil engineering characteristics and other subsurface conditions. Public Safety Criteria prohibits the placement of structures in areas that are severely hazardous to life and property due to soils, geological, seismic, hydrological, or fire factors and whose development would pose a severe hazard to persons or property outside the proposed development. Potential geological, seismic, and hydrological hazards associated with the project both on and off-site are discussed below. As proposed and mitigated, the project complies with applicable Hazards to Public Safety Criteria. Therefore, the project would be consistent with applicable General Plan policies and zoning regulations.

4.3.45 IMPACTS AND MITIGATION MEASURES

4.3.45.1 Significance Criteria

According to the San Mateo County Environmental Checklist and Appendix G of the *State CEQA Guidelines*, a project would normally have a significant environmental impact if it would:

- Involve a unique landform or biological area, such as beaches, sand dunes, marshes, tidelands, or San Francisco Bay;
- Involve construction on slope of 15 percent or greater;

- Be located in an area of soil instability (subsidence, landslide, or severe erosion) or be located on a geologic unit that is unstable, or that would become unstable as a result of the project, and potentially result in on- or off-site landslide, lateral spreading, subsidence, liquefaction or collapse;
- Be located on, or adjacent to a known earthquake fault or expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving rupture of a known earthquake fault, as delineated on the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault? Refer to Division of Mines and Geology Special Publication 42;
- Cause erosion or siltation or substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, in a manner that would result in substantial erosion or siltation on- or off-site;
- Expose people or structure to potential adverse effect, including the risk of loss, injury, or death involving strong seismic ground shaking;
- Expose people or structure to potential adverse effect, including the risk of loss, injury, or death involving seismic-related ground failure, including liquefaction; or
- Be located on expansive soil, as defined in Table 18-1-B of the Uniform Building Code (1994), creating substantial risks to life or property.

4.3.54.2 Issues Not Discussed Further

The Initial Study which addressed the construction of eight homes under the proposed project concluded that the project site does not contain a unique landform such as beaches, sand dunes, marshes, tidelands, or portions of the San Francisco Bay. A discussion of this impact is included in **Section 4.4** of this draft EIR**, Effects Found Not to Be Significant**. Additionally, because the project site lies approximately 3,500 feet east of the San Andreas Earthquake Fault zone, and no known active fault traces or lineaments are known to cross the site, risks associated with rupture of a known earthquake or fault would also be considered less than significant. In addition, the Franciscan Complex bedrock underlying the project site has a very low susceptibility to liquefaction. Therefore, the potential for liquefaction occurring in soil and bedrock at the site during seismic shaking is very low.[17]

4.3.45.3 Project Impacts

Impact GEO-1: **The proposed project would involve development on slopes steeper than 15 percent and could expose people and structures to landslide hazards. (*Potentially Significant; Less than Significant with Mitigation*)**

[17] TRC Lowney, 2006

The proposed project site lies in an area of moderate to steep slopes, slopes that are greater than 15 percent. In addition, ~~one~~ two landslides ~~is~~ are located within the ~~footprint~~ boundaries of the proposed ~~project~~residential lots. The potential for the proposed project to result in new slope instability or landslides and for the project to expose the new structures to existing landslides and associated impacts are evaluated below.

As stated in the Initial Study, average slopes within the project area are 40 percent. Lots 1 through 4 located on the south side of Bunker Hill Drive have existing slope that are moderately steep to very steep (~~1.5:1 to 2.5:1~~2:1 to 3:1, horizontal to vertical). Lots 5 through 8 located on a south-facing slope on the north side of Ticonderoga Drive have slopes that are moderately steep (2:1 to 2.5:1, horizontal to vertical). Lots 9 and 10 are gently to steeply sloping and lot 11 is relatively flat. Prior site investigations conducted by SFS include extensive static and seismic slope stability analyses for slopes around the project. In general, the existing slopes appear sufficiently stable under static and seismic conditions. However, the existing slopes would be altered by the cut and fill associated with the proposed project and the proposed project could result in unstable cut and fill slopes in the Ticonderoga Drive or the Bunker Hill Drive areas. According to design plans for the proposed project, fill slopes are to be constructed at a gradient no steeper than 2:1 and cut slopes would be no steeper than 4:1. Potential problems with cut slopes could include slope failure. The likelihood of these problems occurring is higher when slope inclinations are too steep for the strength of the underlying materials and/or when structure orientation is adverse (i.e., dip of the structure is shallower than slope inclination and dip is out of slope, and when surface drainage is poor). Intensely sheared Franciscan mélange matrix present on the site may be relatively weak and subject to erosion and slope instability when exposed to weathering. Based on design plans proposed for the project, slope failure as a result of project-caused over-steepening would be a potentially significant impact.

Numerous previous studies conducted on the project site investigated the site and its vicinity for the presence of landslides. This information was supplemented by the additional investigation conducted by Treadwell & Rollo in 2009 to better characterize the landslides on the project site. The following existing landslide deposits were mapped in the area.

- A small ~~to moderately~~ sized landslide and a large landslide with deposits covering lots ~~6, 7, and part of lot 5~~5 through 8 ~~is~~are mapped.
- A moderately sized (approximately 300 ft wide) landslide is mapped south of lot 4, about 50 feet south (cross-slope) of the nearest corner of the proposed residence and not downslope of the residence.
- A series of small to moderately sized landslides are mapped within the middle drainage north of the intersection of Lexington Avenue and Ticonderoga Drive.

- A small landslide is mapped southwest of where Bunker Hill Drive meets Polhemus Drive.

Based on the above, existing landslides are not a concern for lots 1 through 4, and lots 9, 10, and 11. ~~Of the existing landslides listed above, the landslide in the area of lots 5 through 7 may potentially extend into lot 8, along Ticonderoga Drive.~~ The supplemental field mapping and investigation determined that lots 5 through 8 are impacted by two separate landslides. Per the Treadwell & Rollo Revised Geologic Evaluation, the landslide ~~in the~~ areas along Ticonderoga Drive ~~is~~are characterized by hummocky topography and ~~an~~ over-steepened head scarps of up to ~~approximately 7~~ 2 to 8 feet in height ~~and is a relatively shallow feature~~, respectively.

The proposed project would involve the construction of ~~three~~ four of the 11 proposed homes in areas with existing landslides. The construction of homes could reactivate these landslides. In addition, a seismic event that subjects the project site to strong ground shaking would increase the potential for landsliding in these previously mapped landslide areas. Without mitigation, the proposed project would not only expose the new structures to risks of slope failure due to the existing slide on the site but would increase the potential for these landslides to be activated. The impact would be potentially significant. However, based on Treadwell & Rollo's 2009 investigation, the smaller landslide that affects lots 5 and 6 would be completely removed during the site grading to construct the proposed building pads and driveways. Therefore, based on current development plans, additional mitigation would not be necessary. The larger landslide affecting lots 7 and 8 would not be completely removed based on the proposed site grades; therefore it would need to be repaired using an appropriate engineering solution. Based on the geometry of the landslide slip surface, Treadwell & Rollo concluded that a conventional buttress fill landslide repair could successfully be used to mitigate the landslide, and that the properly designed repair solution should also remove sufficient driving forces and mitigate further movement of the remaining small piece of the landslide beneath Ticonderoga Drive, thereby reducing the potential for adverse off-site impacts from the proposed development.

In addition to the landslides within the project footprint, a large landslide was also mapped off site west of proposed lots 1 through 4 on the slope ~~on the opposite side of the~~ above the drainage that runs along the south side of ~~proposed lots 1 through 4~~the lots, approximately 50 feet from the lot ~~4 property line~~ residence. Based on site observations during Treadwell & Rollo's supplemental field reconnaissance and mapping, this landslide appears to be relatively shallow and constrained to the colluvium and topsoil mantling the bedrock on these slopes. Based on the location of this landslide to the south of lot 4 and the understanding that the proposed homes would be founded on pier and grade-beam foundations bearing in the underlying sandstone bedrock, the proposed project would not directly affect this landslide and nor would the proposed residences be affected should this landslide be reactivated by other causes. In addition, because of the proximity of the residence to the landslide and because the residence will be founded in the underlying bedrock, the construction of stitch-piers or other type of landslide mitigation is not necessary for the development of these lots. A properly designed drilled-pier foundation will be capable of mitigating any surficial soil movement in the immediate vicinity of the residences on these lots. Other landslides mapped in the project vicinity would not affect the project nor would they be affected by the project.

In summary, for reasons presented above, impacts associated with landsliding and seismically induced landsliding in the project area would be considered potentially significant. Implementation of the following mitigation measure would reduce the impacts of slope instability and seismically induced landsliding to a less-than-significant level.

Mitigation Measure GEO-1: A design-level geotechnical investigation of the site shall be performed prior to any project grading including static and seismic slope stability analysis of the areas of the project site to be graded and developed. The specific mitigation measures to be utilized in order to stabilize existing landslides and areas of potential seismically induced landslides shall be presented in the report. The specific mitigation measures shall include some ~~or comparable measures~~ of the following measures or measures comparable to these:

- Landslide debris on lots 7 and 8 shall be excavated ~~on potentially unstable slopes~~ and replaced with ~~an engineered~~a fully drained conventional buttress fill ~~with subsurface drainage~~that is founded in the underlying Franciscan mélange, as recommended by the project geotechnical engineer. (Lots 7-8)~~. (Lots 5-8)~~

- Retaining walls shall be designed to withstand high lateral earth pressure from adjoining natural materials and/or backfill shall be installed at the rear of lots 5 through 8. In addition, retaining walls shall be built in the front of lots 5 and 6 to aid in maintaining the slopes behind the lots and the more extensive cut required for lots 5 and 6. (Lots 5-8)

- A surface drainage system shall be installed for each lot to mitigate new landslides developing within the thin veneer of soil mantling the bedrock on the slope below lots 1 through 4. (Lots 1-4)

- Subsurface drainage galleries may ~~shall~~ be installed to control the flow of groundwater and reduce the potential for slope instabilities from occurring in the future. (All lots)

- Over-steepening of slopes shall be avoided. Horizontal benches shall be constructed on all reconstructed slopes at an interval of 25 to 30 feet. New fill shall be compacted to at least 90 percent relative compaction (as determined by ASTM test method D1557). (All lots)

- Drilled pier and grade-beam foundations shall be used to support foundations in accordance with recommendations of the project geotechnical engineer. (All lots)

Impact GEO-2: The proposed project is located on a geologic unit that may be unstable or could become unstable as a result of the project. (*Potentially Significant; Less than Significant with Mitigation*)

The discussion of Impact GEO-1 highlights potential landslide hazards at the proposed project site. Because all of the landslide deposits on lots 5 and 6 would be removed as part of project construction, the homes, when built, would not be located on an unstable unit or a unit that could become unstable under seismic conditions. As part of the supplemental investigation, Treadwell & Rollo conducted an evaluation of the static and seismic slope stability of the proposed buttress fill repair solution for the landslide impacting lots 7 and 8. That analysis, contained in full in **Appendix 4.3**, showed that the proposed buttress fill would create conditions on the site that would be stable under static conditions and would experience only a small amount of deformation (slope displacements on the order of 8 to 9 centimeters) under maximum seismically loaded conditions. Treadwell & Rollo concluded that a buttress fill bearing in the underlying mélange bedrock would adequately mitigate slope failure hazards for these lots. Treadwell & Rollo however noted that deformation could be greater if materials with lesser strengths are used in the construction of the buttress fill, and the impact could be potentially significant. A mitigation measure (**Mitigation Measure GEO-2a**) is proposed below to address this potentially significant impact.

Additional instability of underlying units may be attributed to differential settlement, soil creep, increased peak discharges, surface runoff, or the triggering of localized slumps or landslides in response to grading at the site. Of particular concern for the proposed project site are deep fills planned for the development of the project site and the underlying native material that may be subject to differential settlement. Differential settlement could adversely affect the foundations or underground utilities. In addition, SFS investigation of the project site identified a colluvium-filled swale in the lower portions of lLots 2 and 3 and noted that soil creep is likely to occur in this area and on other steep slopes on the project site. Soil creep could adversely affect the foundations of the proposed structures as well as underground utilities and retaining walls. The sandstone bedrock underlying lots 1 through 4 is well fractured, and should promote rapid percolation of surface runoff; however, the mélange underlying the remaining lots is moderately to highly plastic and generally has a low permeability which may result in an increased risk of surface soil saturation during periods of prolonged rainfall. The results of improperly controlled runoff may include foundation heave and/or settlement, erosion, gullying, ponding, and potential slope instability. Therefore, the proposed project could expose structures or persons to risks associated with differential settlement and soil creep. The impact is considered potentially significant. Implementation of ~~the following mitigation measure~~ **Mitigation Measure GEO-2b** would reduce the impacts of development on potentially unstable geologic or soil units to a less-than-significant-level.

Mitigation Measure GEO-2a: Materials used to construct the buttress fill should have effective strength parameters equal to or better than the parameters used in the Treadwell & Rollo 2009 study. (Lots 7 and 8)

Mitigation Measure GEO-2b: The following mitigation measures shall be implemented to ensure the stability of proposed structures that are located on deep fill soils:

- A site-specific, design-level geotechnical investigation shall be completed during the design phase of the proposed project, and prior to approval of new building construction within the site for specific foundation design, slope configuration, and drainage design. ~~This investigation shall include the identification of all areas of potential soil instability.~~ (All lots)

- The geotechnical investigation shall provide recommendations to prevent water from ponding in pavement areas and adjacent to the foundation of the proposed residences, and to prevent collected water from being discharged freely onto the ground surface adjacent to the residences, site retaining walls, or artificial slopes. The project geotechnical engineer shall identify on site areas downslope of the homes where the collected water may be discharged utilizing properly designed energy dissipaters. (All lots)

- Fills used at the project site shall be properly placed with keyways and subsurface drainage, and adequately compacted following the recommendations of the final geotechnical report and Geotechnical Engineer, in order to significantly reduce fill settlement. ~~In particular, alluvial deposits in the southernmost main drainage behind the Hillsborough West Apartments shall be over excavated as recommended by the project Geotechnical Engineer.~~ (All lots)

- Underground utilities shall be designed and constructed using flexible connection points to allow for differential settlement. (All lots)

- Foundation plans shall be submitted to the County for review prior to issuance of a building permit. All foundation excavations shall be observed during construction by the project Geotechnical Engineer to insure that subsurface conditions encountered are as anticipated. As-built documentation shall be submitted to the County. (All lots)

- Drilled pier and grade-beam foundations or other appropriate foundations per the recommendations of the design-level geotechnical investigation shall be developed for lots that are determined to likely experience soil creep. (All lots)

- All work shall be completed in accordance with requirements of the 2007 California Building Code and the County of San Mateo Building Code. (All lots)

Impact GEO-3: The proposed project would not result in substantial soil erosion or the loss of topsoil from grading activities. *(Less than Significant)*

As described above under Impact GEO-1, the project site is located in an area of steep slopes. As a result, site-grading activities would remove vegetative cover and could disturb and expose soil that could become mobilized by storm waters during construction. This could lead to increased sediment load and deposition downstream. According to the USDA soil survey for San Mateo County[18], soils at the site are highly to very highly susceptible to erosion. According to federal law, all construction projects that involve disturbance of more than 1 acre of land are subject to NPDES regulations for stormwater. All such projects are required by law to prepare and implement a Stormwater Pollution Prevention Plan (SWPPP) during construction. The SWPPP must be kept on site during construction activity and made available upon request to representatives of the RWQCB.

The proposed project would involve clearing and grading of approximately 4.53 acres of land. Therefore, the project would be subject to NPDES regulations and would be required to file a Notice of Intent with the State Water Resources Control Board and the construction contractor for the project would be required to prepare and implement a SWPPP during the construction of the proposed project. As described in **Section 3.0, Project Description**, the proposed project includes an erosion control plan pursuant to which stormwater controls will be implemented during project construction to minimize erosion and sedimentation. Therefore, the impact related to soil erosion and loss of top soil during project grading would be less than significant. However, an improvement measure is included below that would ensure that the impacts of erosion would remain less than significant.

Improvement Measure GEO-3: In compliance with the NPDES regulations, the Project Applicant shall file a Notice of Intent with the State Water Resources Control Board (SWRCB) prior to the start of ~~construction~~ grading and prepare a SWPPP.

The SWPPP shall include specific best management practices to reduce soil erosion. The SWPPP shall include locations and specifications of recommended soil stabilization techniques, such as placement of straw wattles, silt fence, berms, and storm drain inlet protection. The SWPPP shall also depict staging and mobilization areas with access routes to and from the site for heavy equipment. The SWPPP shall include temporary measures to reduce erosion to be implemented during construction, as well as permanent measures.

County staff and/or representatives shall review the SWPPP to ensure adequate compliance with State and County standards.

County staff and/or representatives shall visit the site during grading and construction to ensure compliance with the SWPPP, as well as note any violations, which shall be corrected immediately. A final inspection shall be completed prior to occupancy.

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18 Soil Survey for San Mateo County - Eastern Part, and San Francisco County, CA

Impact GEO-4: **The proposed project could expose people or structures to potential adverse effects, including the risk of loss, injury, or death involving strong seismic groundshaking.** ***(Potentially Significant; Less than Significant with Mitigation)***

There is a high probability that the project site will be subject to violent ground shaking from an earthquake during the life of the project. Ground shaking for a particular site can be described in terms of ground acceleration as a fraction of the acceleration of gravity. The California Geological Survey Probabilistic Hazards Assessment predicts peak ground acceleration at the site of 0.672 g, with a 10 percent chance of exceeding that value in 50 years. This acceleration would shake structures in the development violently. Therefore, seismic shaking at the proposed project site could cause damage to structures, especially structures that are unprotected or poorly designed. As a result, seismically induced ground shaking is considered a potentially significant impact. To reduce this potential impact to a less-than-significant level, the following mitigation measure will be implemented.

Mitigation Measure GEO-4: The Project Applicant shall be required to use the seismic design criteria listed below to design structures and foundations to withstand expected seismic sources in accordance with the California Building Code (2007) as adopted by the County of San Mateo.

Site Class	C
Soil Profile Name	Very Dense Soil and Soft Rock
Occupancy Category	II
Seismic Design Category	E
Mapped Spectral Response for Short Periods- 0.2 Sec (S_s)	2.226 g
Mapped Spectral Response for Long Periods- 1 Sec (S_1)	1.273 g
Site Coefficient- Fa, based on the mapped spectral response for short periods	1.0
Site Coefficient- Fv, based on the mapped spectral response for long periods	1.3
Adjusted Maximum Considered EQ Spectral Response for Short Periods (S_{MS})	2.226
Adjusted Maximum Considered EQ Spectral Response for Long Periods (S_{M1})	1.655
Design (5-percent damped) Spectral Response Acceleration Parameters at short periods (S_{DS})	1.484
Design (5-percent damped) Spectral Response Acceleration Parameters at long periods (S_{D1})	1.103

Impact GEO-5: The proposed project could potentially expose residents to substantial risks to life or property from development on expansive soils. (*Potentially Significant; Less than Significant with Mitigation*)

Much of the bedrock beneath the proposed project site is serpentine of the Franciscan Complex. Serpentine bedrock can generally form expansive clay soils due to the high magnesium content of the rock. Soils currently present on the project site are found to have a low expansion potential,[19] but due to the presence of bedrock and related soils that may have moderate to high plasticity beneath these surficial layers, expansive soils could be locally exposed during construction. Expansive clay soils are potentially damaging to foundations since they shrink and swell in response to changes in moisture content. The subsequent movement can lead to cracking and settlement of foundation elements that could eventually undermine structures. Because grading for the proposed project could involve the possible local exposure of expansive soils, this impact is considered potentially significant. Implementation of the following mitigation measure would reduce potential impacts of expansive soils to a less-than-significant level.

Mitigation Measure GEO-5: During site grading, soils in each lot shall be observed and tested by the project Geotechnical Engineer to determine if expansive soils are exposed. Should expansive soils be encountered in planned building or pavement locations, the following measures shall be implemented under the direction of the Geotechnical Engineer in order to mitigate the impact of expansive soils:

- Expansive soils in foundation areas shall be excavated and replaced with non-expansive fill to the specifications of the geotechnical engineer.
- A layer of non-expansive fill soils 12 to 24 inches in thickness shall be placed over the expansive materials and prior to the placement of pavements or foundations.
- Moisture conditioning of expansive soil shall be applied to a degree that is several percent above the optimum moisture content or lime treating of the expansive soil.
- Foundations shall be constructed to be below the zone of seasonal moisture fluctuation or to be capable of withstanding the effects of seasonal moisture fluctuations.
- Specific control of surface drainage and subsurface drainage measures shall be provided.
- Low water demand landscaping shall be used.

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19 Preliminary Geologic/Geotechnical Investigation Report for Highland Estates, Soil Foundation Systems, Inc. September 1990.

4.3.5.4 Cumulative Impacts

Impact GEO-6: The implementation of the proposed project would not substantially contribute towards cumulative geology and soils impacts in the project area. (*Less than Significant*)

Geology and soils impacts for future development in the project vicinity and County would involve hazards associated with site-specific soil conditions, erosion, landsliding, seismically induced landsliding, liquefaction, and other site-specific geological impacts. Regional impacts such as seismically induced ground shaking would affect individual sites independently. Future geological impacts for each development in the project area would be site specific and residents, employees, or other site users would not share with or contribute to impacts on other sites. In addition, development on each site would be subject to the California Building Code (2007) (CBC) requirements and construction standards that are designed to protect public safety and reduce geologic and soil impacts. Therefore, cumulative geology and soils impacts would be considered less than significant.

Mitigation Measure: No mitigation measures required.